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# THE BACTERIOLOGY OF THE BLOOD OF DOGS WITH ECK FISTULA

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There is an impression, supported by considerable evidence, that organisms from the bowel often enter the portal stream and in the liver are effectively disposed of. In order to test this point it was thought that Eck fistula dogs might furnish proper conditions; at least, it would be of interest to note whether or not bacteria appeared in the general circulation or possibly caused occasional infections in the lungs or elsewhere in such animals.

An Eck fistula is an artificial communication between the portal vein and the vena cava with the portal vein ligated above the anastomosis just at the hilus of the liver. This operation destroys the portal circulation so far as the liver is concerned, in that now the flow of blood from the abdominal viscera (except the kidneys and the suprarenal glands) is returned to the general circulation without passing through the capillaries of the liver; in other words, the liver is shunted out of the portal circulation and receives its sole blood supply by way of the hepatic artery, which carries about one-fifth of the quantity of blood that is carried by the portal vein.

The anatomic situation of the liver naturally suggested to investigators a protective function. Under normal condition all the products of intestinal digestion and other absorbable substances (except the greater part of the fats) must first pass through the liver capillaries before reaching the tissues in general, while under the conditions imposed by an Eck fistula they reach the tissues first. It has been amply proved that the liver exercises a protective function against certain poisons absorbed from the alimentary tract, especially against certain of the products of protein digestion, such as ammonia. In fact, dogs with Eck fistulas will not tolerate a heavy meat diet.

To prove whether or not bacteria actually pass the bowel wall into the circulation and, if so, what influence the liver has on them, we instituted the following experiments on dogs with Eck fistula.

June 25, an Eck fistula was made in a dog weighing 19,000 gm. Recovery was prompt without infection; some emaciation followed. On July 9, 12, 13 and 16 from 5 to 10 c.c. of blood were drawn from the femoral vein under sterile precautions and introduced into 3 or 4 culture tubes of broth. Of the tubes inoculated, only one taken on the first day yielded a slight growth of a nonhemolytic small streptococcus.

An identical experiment was made with a second dog with Eck fistula operated on July 4. The cultures were made on July 12, 13 and 16. The various tubes were inoculated with the blood as in the first experiment, and all remained sterile indefinitely. These experiments were more or less in the nature of preliminary tests to determine whether or not bacteria in dogs with Eck fistula passed through the bowel wall and remained in the circulation for any length of time. The results we regard as negative. In only one of the tubes did we obtain a slight growth of a small coccus which we believe to be a contaminator.

In the next experiment the conditions were altered somewhat. On July 10, an Eck fistula was made in 2 normal dogs by one of us (Mathews). No untoward results followed the operation. Seventeen days later when healing was complete blood was drawn, with proper precautions, from the femoral vein. From each dog about 5 c.c. of the fresh blood was introduced into 4 large tubes containing 50 c.c. of ascites broth; 2 were placed under anaerobic and 2 under aerobic conditions. The tubes were kept under observation for a period of 2 weeks and in none did a growth occur. The dogs in this experiment were bled 2 hours after a rather heavy meal of meat, with the idea that possibly the absorption might favor the passage of bacteria through the bowel wall. Evidently this is not the case.

Again on Aug. 2, 23 days following the operation the 2 dogs were bled from the right side of the heart by needle puncture. Some of the blood thus obtained would come directly from the portal circulation without passage through either the liver or lung capillaries.

This time the dogs were bled 4 hours after eating heavily of meat. Cultures were made in ascites broth as before and observed from time to time. No organisms grew in any of the tubes either under aerobic or anaerobic conditions. The results of both of these experiments, then, were negative for the circulating blood of these animals under the condition stated.

Blood from these dogs was then examined bacteriologically after the introduction of cultures of bacteria into the stomach. The bacteria were introduced by means of the stomach tube and 100 c.c. each of the 48-hour cultures of *B. pyocyaneus* and *B. subtilis* were so given to both dogs on a fasting stomach. After 4½ hours, from the heart of each dog 10 c.c. of blood were removed by needle puncture and introduced into 4 broth tubes in diminishing quantities. Neither *B. subtilis* nor *B. pyocyaneus* was obtained from any of the tubes following incubation. From dog 1 a small coccus grew slowly in 2 tubes which was not identified. From dog 2 a larger coccus grew profusely in one tube in 24 hours. We felt justified in regarding these as contaminations.

A week later the same experiments were repeated and 10 c.c. of blood were taken from the heart for culture at the end of 1 hour, 2 hours and 5 hours. Four broth tubes were inoculated from each sample of blood and 2 were placed under aerobic and 2 under anaerobic conditions. These cultures all remained without growth of *B. pyocyaneus* and *B. subtilis*. In 2 instances a small coccus appeared in few numbers, similar to the one obtained previously and which was regarded as a skin saprophyte.

About one week following this experiment the dogs were killed and examined. The Eck fistulae were in perfect condition. No important change was noted in the organs.

The next experiment was designed to compare the length of time bacteria artificially introduced into the circulation remain in dogs with Eck fistula and in normal dogs. In dog 1, several days following the last experiment 8 c c of a 36-hour broth culture of a staphylococcus albus was injected intravenously. As a control, at the same time a normal dog of approximately the same weight was injected with a similar amount. Blood cultures were made at short intervals from both dogs. The results are presented in table 1.

Between 2 and 3 hours after the injection both dogs became sick and vomited. After 24 hours they appeared quite normal. It will be noted that the staphylococci in 24 hours had disappeared from the blood, and at the end of 5 hours had somewhat diminished. It is possible that had many more cultures been made, slight differences might have been detected. It is apparent, however, that no appreciable differences appeared in the elimination of bacteria by the 2 dogs. A second similar experiment was made. Accidental contamination of some of the plates occurred, but so far as the results could be determined, they correspond with those of the first experiment.

TABLE 1  
LENGTH OF TIME BACTERIA, ARTIFICIALLY INTRODUCED, REMAINS IN NORMAL DOGS AND IN DOGS WITH ECK FISTULA

Time After Injection	Growth from Normal Dog	Growth from Dog with Eck Fistula
5 min.	+++	+++
10 min.	+++	+++
15 min.	+++	+++
30 min.	+++	+++
1 hour	+++	+++
2 hours	+++	+++
3 hours	++	++
5 hours	++	++
24 hours	0	0

In this connection it may be mentioned that dogs with Eck fistula do not appear to be especially susceptible to infection. During a period of 10 years, one of us (Mathews) has had under observation about 100 dogs with Eck fistula, living from a few weeks to 3 years and noticed no more tendency to infection than in normal dogs. One thing noted, however, was that about 10% of these dogs failed to maintain a normal state of nutrition regardless of food or hygienic care. They suffered from diarrhea, and the stools were fatty and similar to the bowel discharges following ligation of the common bile duct. These dogs died in an extreme state of inanition after 2 or 3 months. Ulcers of the duodenum were observed in 5, and perforation was the immediate cause of death in 2. The diarrhea and fatty stools were probably due to a suppression of the formation of bile, which has been observed by Voegtlin and others in dogs with Eck fistula.

The obvious relation of the entrance of bacteria to the problem of so-called focal infection need only be mentioned. In spite of the negative character of our data, the suggestion is here offered that in a given case in seeking the source of the infection we should not overlook the possibility that the bacteria entered the body along a route long since closed with no evidence now of its past existence. Or they may have passed through the intact membrane without causing any local alterations, as tubercle bacilli may do for example, in passing through the intestinal wall.

Our results in general are in accord with observations made by many on the relatively rapid disappearance of bacteria when introduced into the circulation. Bull<sup>1</sup> has called attention to the intravascular agglutination of bacteria and their subsequent accumulation in the lungs, liver, and spleen. The endothelium, especially in certain organs, is most active in the destruction of the organisms.

Bartlett and Osaka,<sup>2</sup> investigating the fate of micrococcus aureus in normal dogs, came to the conclusion that they are rapidly stored up in large numbers in the lungs following injection into the left ventricle. A little later they disappear in the lung and appear in considerable numbers in the spleen and liver but again disappear from here in from 48 to 72 hours. In blood, bone marrow, lymph nodes, muscles, etc., they are found in small numbers or not at all. Their method of detection was by means of sections, and they reported no cultural results.

In dogs with Eck fistula in all probability the bacteria in the circulation, however they may have entered, are disposed of by the various mechanisms referred to. It seems that no appreciable differences occur in this respect between normal dogs and those with Eck fistula. Though the amount of blood that flows through the liver is markedly diminished in the latter, apparently this does not appreciably alter the general rate of destruction of the bacteria, since so many cells and organs other than the liver are concerned in this process.

#### SUMMARY

Experiments do not indicate that in dogs with Eck fistula bacteria in any appreciable numbers appear in the circulation.

Dogs with Eck fistula are no more susceptible to infection of the lungs or of other organs than are normal dogs.

Bacteria disappear from the circulation as rapidly in dogs with Eck fistula as in normal dogs.

<sup>1</sup> Jour. Exper. Med., 1915, 22, p. 475.

<sup>2</sup> Jour. of Med. Res., 1916, 35, p. 465.